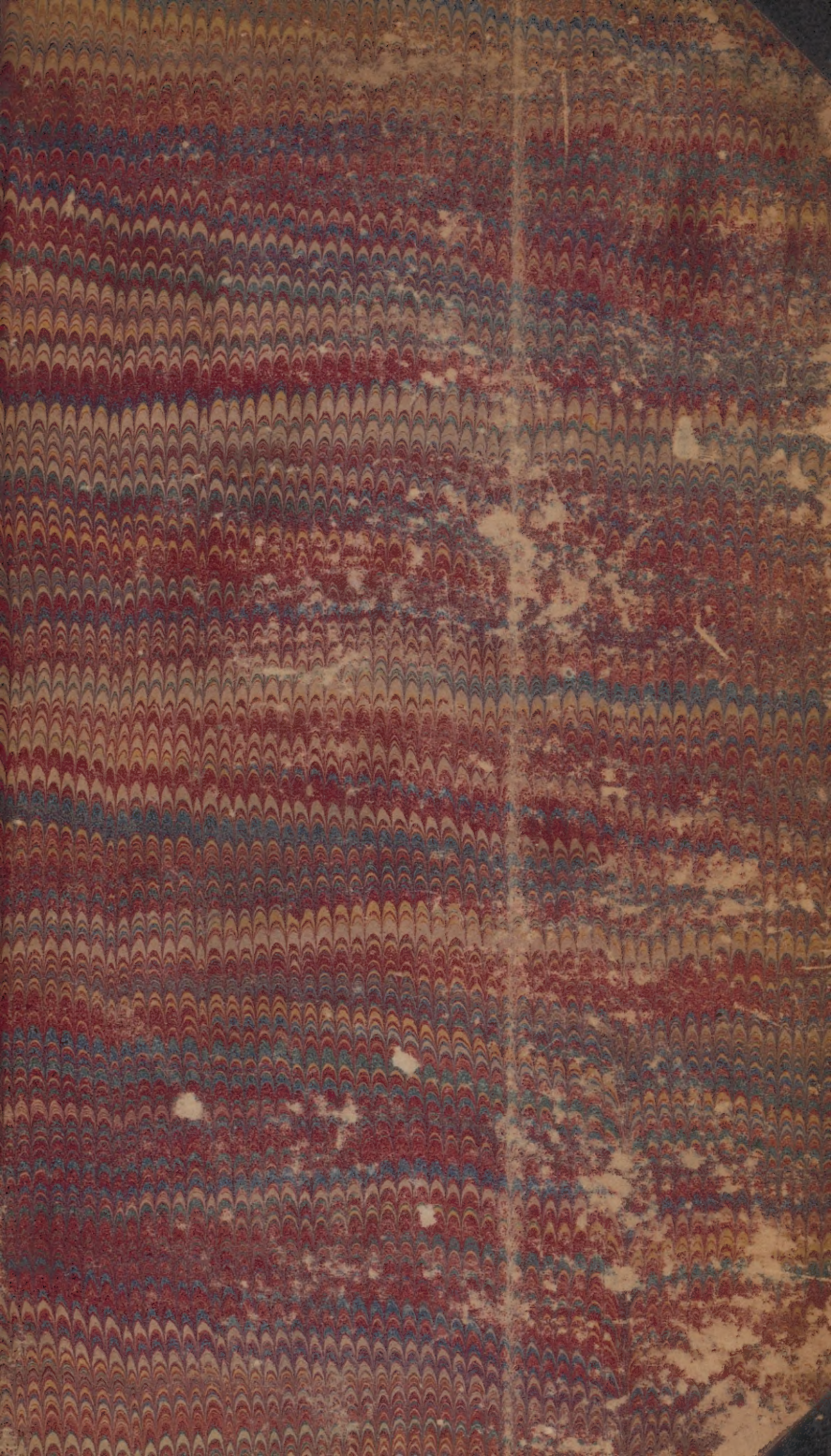






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AN ESSAY  
ON  
ORGANIC, OR LIFE FORCE.

WRITTEN FOR THE DEGREE OF DOCTOR OF MEDICINE IN  
THE UNIVERSITY OF PENNSYLVANIA.

BY

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AN ESSAY

ORGANIC, OR LIFE FORCE.

THE EVOLUTION OF THE HUMAN MIND.

PHILADELPHIA:

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## AN ESSAY.

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I PROPOSE to write a thesis upon the Force of the Germ, which converts a formless material into an Organized Structure. That a germ is necessary to life action is now well established, and the doctrine of *spontaneous generation* is entirely exploded. But the origin of the Germ is not so well established as the necessity of its existence. The view which will be taken of the origin of Germ, or Life Force is, I think, somewhat novel. This view is taken both on account of the amount of direct and analogical evidence in its favor, and because it seems to explain the phenomena of Life.

Perhaps no subject attracted the attention of man earlier than that of his own existence; yet no subject has been more willingly granted to be beyond investigation than the means by which Life is effected, or the principle of action in his own body. Almost to the present time he has been contented to refer all the phenomena of life to an unknown "Vital Principle," independent of the organism. Time has been spent in seeking the seat of this unknown agent, rather than in investigating the principle of life itself, and it has been variously referred to the brain, the spinal cord, the solar ganglion, the heart, the blood, &c. &c. That there are mysteries connected with life which never can be penetrated by the mind, does not distinguish it from the inorganic world. In pursuing any subject, the mind is soon arrested by an impenetrable barrier; but it is important to be observed that nothing is placed out of the reach of man that would be of advantage to him in his present condition. The expansibility of water by heat into steam, and the laws of its expansion are open to investigation, and the advantages of this property of water are inestimable; but it would be of no advantage to know *why* water is thus expansible; and this question could only be answered by saying—it is so, because God willed it so. Thus it is in every subject, though sometimes the chain may be a little lengthened by explaining words by words, yet the mind is at length inevitably lost in the first great *Law*, which is the *Creator's Will*. In every investigation it is important to find where the barrier to the mind is placed, so that time may not be lost in seeking that which was intended for us never to know, at the same time, that that may not be left unsought which was intended to be understood. The fact that life is enveloped in mystery, is no reason for excluding it from the field of investigation. Rather, this is the very reason it should be a subject of study, as it is of the utmost importance to know the principle upon which a machine acts, to be able to correct abnormal actions. The machines of art are but the means by which *man* takes advantage of the laws of matter to obtain certain objects. He can no more obviate these laws, or add anything to them, than he can create a universe. An organism is but a machine, by means of which the Creator himself takes advantage of the laws with which he has endowed matter



to effect certain objects which are the designs of God and not of man. It would be of no advantage to know whether living beings were the object for which matter was created with its existing laws and properties, or whether there was no such object in the Creator's mind; and this is not a subject of investigation, though it may be of speculation. It is enough for us to know that the organism is a machine which acts in perfect accordance with the laws of matter; and is not overruled by some unknown independent agent—the "vital principle;" that life is the necessary result, when the organism is placed under the proper conditions; and that this result grows out of the particular combination of the matter constituting it. But if there is no mysterious agency in the living organism to make its actions different from that which would result from the properties of the matter constituting it, then the principles upon which this organism acts, are as much open to investigation as that of any other piece of machinery, but it is more difficult as its actions are more complex.

Taking this view of the subject, I shall venture to offer the following proposition, and shall give a few arguments in support of it, which have been sufficient to convince me at least of its truth.

*Life, or the Actions of an Organism are produced by Forces which are evolved in the decomposition or decay of that Organism.\**

When we look into the organic world, it is observed that the natural tendency of all organic matter, under the influence of the external conditions of life, is to resolve itself into simpler compounds; but in the living organism there is an action directly contrary to this observed natural tendency. It was, no doubt, from this *apparent* reversal of the laws of matter, that first originated the idea of an independent agent residing in the system, whose office it was to overrule these laws, and give direction to vital actions. It is, no doubt, from this, that even to the present time, the "vital principle" enters into the explanation of all vital phenomena. The attention of physiologists has been almost exclusively directed to the building up of the organism. Disintegration has been thought worthy of attention only as it is modified by this "vital principle," or, as it makes continued nutrition necessary. As decay is common to all organic matter, the attention has been diverted from this to organization, which is peculiar to living beings; and nutrition is looked upon only as a means of "counteracting" the "destructive" tendency to decay, rather than as affording a necessary condition to continued decay. Though we cannot conceive the existence of a living being without change, yet this tendency to change has been considered destructive, rather than essential to life. It is thought that it will appear from what is to follow, that the arrest of the natural laws of matter in a living organism, is more apparent than real; that vital actions are as much the result of these natural laws as are death and decay; and, that death and life have the relation to each other of antecedent and consequent. Though death is so common and so *natural*, that we are accustomed to look upon it as a matter of course, yet it is no less difficult to tell why we die than why we live; both are but evidences of the Creator's will. We are constantly dying while we are living, and to arrest decay would be to arrest life.

While Dr. Carpenter ridicules the theory of a "Vital Principle," he seems to fall into greater difficulties than he has obviated, when he offers as his theory the following: *The dormant vital properties originally stamped upon*

\* The word *organism* in this essay is not restricted to its usual acceptation, but includes the granules or germs—though *apparently* formless—from which cells are developed under proper conditions.



*matter capable of assimilation, are developed by the very act of organization.\** He gets over the objection which would naturally arise to this theory, that Life Force must have existed *prior* to the *act of organization*, in a very summary manner; as also, the objection arising from the *universal* tendency of organized matter to resolve itself into simpler, rather than into more complex compounds. While the views contained in this article are directly opposed to the theory of a "Vital Principle," they are equally opposed to the theory that *matter was originally endowed with vital properties, which are developed by the act of organization*. These views are, that in an organism, the act of resolution of a complex into simpler compounds, evolves forces which give direction to chemical and organic actions, and, as life is the result, the terms Organic, Germ, or Life Force may be employed to indicate the resultant of these forces. This force is produced when the conditions of life—the germ, air, heat, and a fluid plasma—co-exist. If the above proposition be true, life is not derived from the parent, but originates in the changes which take place in the Germ itself. It has been the doctrine of some that *germ force* is derived from the male parent; of others, from the female; while others again hold that it is produced by both parents at the same time, and by the same act that the germ is. But there are reasons to believe that *germ force* is no more derived from either parent than galvanic force is derived from the individual who constructs a battery.

We will now proceed to consider a few arguments in support of the proposition before stated—that *Life, or the actions of an organism are produced by forces which are evolved in the decomposition or decay of that organism*.

1st. This proposition is shown not to be absurd, at least, by reference to Inorganic Chemistry. The chemical properties of matter are developed by chemical action only, and this action is necessarily destructive to the constituents as such. For instance, combustibility is a property of carbon and hydrogen, while oxygen is a supporter of combustion. These properties are developed by the act of combustion only, which action destroys the constituents as such, and there results compounds entirely different—carbonic acid and water. It would seem as philosophical to say the explosive property of gunpowder is developed by the act of manufacturing it, as to say the properties of an organism are developed by the "*act of organization*." But it may be said, although chemical properties are developed by chemical action, which is necessarily attended with change, yet, as caloric is evolved by the act of forming carbonic acid and water from their constituents, so life may be produced by the "*act of organization*." The cases are entirely different; there is an affinity between carbon, hydrogen, and oxygen, which is the *force* disposing them to unite, while in an organism the tendency is to separation, and consequently there must be a force to produce organization, instead of that force being produced or developed by the "*act of organization*." It is difficult to understand how vital properties can be developed by the act of organization, when the natural tendency is to disorganization, unless it be assumed that there can be an effect without a cause, and that actions can take place not only without a force to produce them, but even in direct opposition to existing forces. This certainly is a greater supposition, and more difficult to believe than that of an independent Vital Principle which may counteract the natural laws of matter; but it is confessed that neither of these theories is very satisfactory.

The tendency of organized structures to decay, when under the influence of air, heat, and moisture, is the starting force, which, when a fluid plasma is

\* Article *Life*, in the Cyclopædia of Anatomy and Physiology.



present, the organism appropriates to its own actions. To explain this point, let us take carbon and oxygen for instance. These elements unite and form carbonic acid, which is the result of the chemical action, and may be collected, weighed, and tested, and found to possess all the properties of matter. But carbonic acid is not the only result of this chemical action. The causes of the phenomena of heat and light, and no doubt of electricity too, are evolved, and we know not how many other forces which have not yet been recognized. The same may be said of the action in a galvanic battery, and of all other chemical actions. If the battery be charged with dilute sulphuric acid, the material result of the action, would be the sulphate of the oxide of zinc, which possesses all the physical and chemical properties of this compound. But it must be observed that the causes of the phenomena of electricity, heat, and light are evolved in this chemical action; at least these phenomena become manifest under proper conditions, and result from the chemical action. Now, it may be said that chemical action results from chemical affinity, or a disposition between bodies to unite; so the tendency of oxygen to unite with carbon is not only the force by which carbonic acid is produced, but it is indirectly the cause of the evolution of heat, light, and electricity. When this is applied to the organism, we can understand how its tendency to resolve itself into simpler compounds by uniting with oxygen, may be the starting force from which all its other actions are secondary results; each action affording the necessary conditions for the actions which follow. We can understand how decay or oxidation may afford conditions, under the influence of which, life and organization as necessarily and naturally result, as do decomposition and decay in an organized structure under the influence of conditions afforded by air, heat, and moisture. Ammonia, carbonic acid, &c., are the chemical results of decomposition; but, as in the inorganic world, so here chemical action is attended with the evolution of electricity and the causes of heat and light, and it may be with various other forces which have not yet been recognized.

The fact that chemical action is attended with evolution of heat, light and electricity, proves that these agents are *separable* from matter, and are subject to variations according to certain laws. It is foreign from my object to take either side of the moot-question respecting the identity of chemical affinity and the electric condition of matter, but incontestable facts prove that chemical actions may be produced through the agency of heat, light, and electricity, and that these actions may also be *reversed* through their agency according to definite laws. To illustrate this point, it is necessary only to notice the constituents of water. Oxygen and hydrogen may be associated for an indefinite length of time without exhibiting the least tendency to unite, but when a *flame* is applied, they unite explosively. Pass an *electric current* through the water thus formed, and it resolves itself into its original elements, which may be again united and then re-resolved as before, and so on. The decomposition and recomposition of water through which an electric current is passed, as shown by the fact that the ions are given off at different electrodes, is a good example of reversed action by means of electricity. Hence, we have the same reasons to suppose that there is a natural tendency in water to resolve itself into its constituents, as to suppose that there is a natural affinity between oxygen and hydrogen independently of external circumstances. It is said that there is such an affinity; *but*, their elasticity prevents the particles from coming within the sphere of attraction; if this be the case, it is strange that heat, which would *increase* their elasticity, should cause their union. Again, the *diffusion of gases* is explained by supposing that gases are *not* repulsive to each other, while the fact that they do not unite of themselves, is explained



by supposing that they *are* repulsive to each other. Whether affinity be inherent in matter, or whether it be due to certain agents which are *variable*, and which may be increased or diminished by external circumstances, the present question has but little to do with. But it has much to do with certain *facts* which were illustrated above. Heat and electricity are evolved by oxydation; oxygen and hydrogen do not unite of themselves; under the influence of *heat* they unite explosively, and the water thus formed is resolved into its constituents by *electricity*. So, in an organism there is no tendency either to decay or organization except it be under the influence of air, heat, and moisture; but under the influence of these circumstances, the natural tendency is to decay; but decay or oxydation evolves heat and electricity, under the influence of which, organization is the natural result, as the oxydation of one metal evolves a force which will *deoxydize* another. Heat, which produces oxydation, is evolved by the oxydation of something else; so electricity, which produces deoxydation, is evolved by oxydation, and there is no more difficulty in explaining why the conditions afforded by decay should produce organization, than why the conditions afforded by air, heat and moisture should produce disorganization.

The object of the foregoing argument has been to show that, according to the universal law of chemical action, the properties of an organism could not be developed except by *disorganization*; secondly, to show that, when it is said that forces are evolved by the decay or oxydation of the organism, entirely distinct from the chemical compounds that result, nothing is assumed which is not exemplified in every chemical action which takes place, whether in the organic or inorganic world; and thirdly, to point out the fact that in inorganic chemistry, oxydation evolves a force which produces deoxydation, and thus to show it possible, that disorganization—which is the oxydation of the organism—may evolve forces which produce organization. But,

2d. Wherever there is life there is decay, and in health, decay is always in proportion to the vital activity. This shows some necessary connection between the two, and a possibility that there may be some truth in the foregoing proposition. It may be said, if the proposition be true there should be life wherever there is decay. But not so; if an acid be thrown upon zinc, oxydation takes place, but there are no electrical phenomena unless there be a peculiar arrangement with another metal; so it is only under a peculiar arrangement, as in an organized structure, that decomposition and decay give rise to vital phenomena.

Change is essential to the very idea of life. From the lowest plant consisting of a single cell, to the highest animal, there is constant change and decay so long as there is life. In plants there is constant decay in the leaves, and it is well established that the growth of the more permanent woody structure is dependent upon these changes which take place in the leaves. The cells of the leaf, whose office it is to prepare the nutritious fluid, are but transitory; in all cases, the vital activity corresponds with the activity of decay. As the solid woody structure is permanent, so it *does not* participate in the life of the plant, or generate life force. The woody tissue is the object obtained by means of life action in cells of brief duration, while it does not itself participate in these actions. In animals, force is required not only for the performance of the organic functions, as in plants, but also for the performance of the animal functions. Now there is no fact better established in physiology than, in the exercise of the animal functions, the *destruction* of the organ is directly in proportion to the activity of the functions. There can be no doubt but the final cause of the exercise of organic functions in animals is, so far as the *individual* is concerned, to supply and keep up the conditions

for the exercise of the animal functions; yet it is no less true in animals than in plants, that the exercise of *organic functions* in them is also attended with decomposition and decay in proportion to their activity. In the young, the tissues are soft, and decay is rapid, and the vital actions are correspondingly active; while in the old the tissues become more firm and permanent, and the vital actions are consequently less vigorous. In the former, the repair of injuries is rapid, and, if the cause of disease be removed, the restoration to health is quick and entire; but in the latter, the structure is firm, decay is slow, the vital energies are correspondingly low, and if there be a restoration, it is tedious and often but partial. From the beginning of life to the end of it, there is a constant relation between decay and life-action. It has been considered that decomposition of the muscular and nervous tissues results from their functional activity: if the proposition here advocated be correct, their functional activity results from decomposition and decay, or from forces evolved in this process. A machine of art acts more easily and with less friction when composed of a hard material; while in the organism, as the tissues become more firm the actions are less; hence this must be because there is less force to produce the actions; but there is a constant relation between the decay and the actions of an organism; hence it would follow that the destruction does not result from the action, but the action from the forces evolved in its oxydation. The relation preserved in health between decay and renewal, is so constant that it cannot be believed a mere accident. As decay and renewal are directly opposite to each other, they cannot be dependent upon the same cause; hence as the relation is so constantly preserved, the one must be dependent upon some condition afforded by the other. Now, as the natural tendency of the organism is to decay, and, as there could not be renewal previously to decay, it is most probable that decay affords the necessary conditions to renewal; that is, the very act which creates a necessity for renewal, also evolves the forces necessary for its accomplishment.

3d. The above proposition seems somewhat plausible when we consider that the same conditions which are necessary to decomposition and decay, are conditions necessary to life. Under the very same circumstances we have life manifested in one organic compound, and nothing but destruction in another; while, without these circumstances there is neither Life nor Destruction in either. Can this be because air, heat and moisture are conscious existences, and have not the same tendency in the two cases? Can it be that they have in the one case a *deadly*, while in the other a *vitalizing* influence? It would seem not; although vital actions do result from the influence of these conditions in the one case, yet it would appear that this can only be effected through decay; for their tendency to *destroy* and *disorganize* must be the only way through which they exert their influence throughout the organic world. Take a seed for instance; if it be preserved from the conditions of decay, it will remain unchanged for any length of time; but so soon as the influence of these conditions operates, Life is manifested—an act of *organization*, which is directly contrary to the admitted natural influence of these conditions. It is not an object here to define the forces which produce vital action; admit if you please the existence of an independent “vital principle;” or if you would rather admit that “matter capable of assimilation was originally endowed with vital properties;” or let there be any hypothesis which may enter into the heart of man to conjecture, the argument is the same; that the forces which produce vital actions, be they what they may, are developed by means of the oxydation or decay of the organism, just as electricity, heat and light are evolved by the oxydation of zinc. As the external conditions of Life are the same as those of Decay, the different results must proceed



from difference in the substances acted upon; and as the tendency of these conditions is to produce disorganization rather than organization in *all* organic compounds, and as there is decay wherever there is life, Decay must be a necessary antecedent to Life. But an *organized structure* is so arranged by an Infinite Wisdom, that in it the very act of incipient destruction liberates a recuperative life force, which, if there be a supply of nutriment, *renews* and builds up the structure, every particle of which is, in its turn, destined to *decay*, and thus acts its part to keep up the actions of the individual.

4th. Further evidence in favor of this proposition, derived from the fact that it obviates some objections which hold against other theories. While Dr. Carpenter abandons the venerable phrase "the vital principle"—as a support to the mind in explaining the phenomena of life, he does not seem to have afforded the shadow of a substitute in his theory, that matter was originally endowed with *vital properties* which are developed by the act of organization. But more, there are marked objections to this theory, which not only do not hold against, but strongly corroborate the one here advocated. The first to be noticed is the constant tendency of organized structures to disorganization. Now for the "act of organization" there must be a force exerted more than sufficient to counteract this tendency in the part that is in the act of organization. Can the "act of organization" be at the same time the *effect* and the *cause* of this force? But it is said that decay takes place the same in the living as in the dead body, but in the former the effects are "counteracted" by constant renewal. This is begging the question, for if decay were not in some measure obviated by a counter force, there could be no renewal. From the previous arguments it appears possible that this counter force may be evolved by decay itself; not decay in the part that is in the act of organization, which would be absurd; but in a single cell, for instance, the decay of the *exterior* liberating forces, which carry the *interior* to a higher state of organization, as in inorganic chemistry, the *oxydation* of one metal liberates a force which produces the *deoxydation* of another. The fact that life force is evolved by decay, accounts for the equilibrium between decay and renewal preserved in health. If any cause should tend to diminish decay, life force would diminish accordingly, and the structure would be less preserved against the *ordinary* influences, while if any cause increase decay, life force is increased, and the structure is more preserved in proportion to the greater cause of decay. We have here the law by which the system tends to preserve health, but more on this point hereafter.

Another objection to this theory is that the "act of organization" is itself a vital action, and therefore implies the pre-existence of life force. So, according to this theory, we have the manifestation of a force *before* the act by which it is developed. Even the "vital principle" would be of service to fall back upon here, but alas! it had been previously swept away. We can only infer the existence of a force from the action produced, and if the author meant by the word "develop" that we become *aware* of the existence of life by the "act of organization," there need nothing be said for it or against it; for it is a self-evident proposition. But that matter capable of assimilation was *originally endowed with vital properties*, and that *these vital properties* become manifest by the act of organization is not quite so clear. What more need be said in refutation of this theory, than that the "act of organization" is *itself* the sum and the substance of all that is strictly *vital*? If the act of organization be vital, it must be produced by an agent which may be called life force; but if the natural tendency be to disorganization, then this force must be evolved by some means prior to the act of organization. The subject of the endowment of matter originally with *vital properties* will be taken up

in the next and subsequent arguments, and I think it will appear that there is no such thing as a vital property independently of the organism; that what is called "life force" is the resultant of the *ordinary* forces of matter as combined in an organism. It need only be said here, if matter was originally endowed with vital properties, then it was also originally endowed with nitric acid properties, with prussic acid properties, and with the properties of all the compounds capable of formation, and these properties are developed by the *act of forming the respective compounds*. This theory would seem open to as much ridicule, as its author has thrown upon the theory of a "vital principle" which certainly deserved respect, at least on account of its age.

The object of the foregoing arguments has been to present some things which are not entirely satisfactory in the various theories of life, and in some measure to do away with the prejudice against a new theory. It has been also to show that the proposition stated in the beginning is not entirely absurd, but somewhat plausible, and worthy of study to confirm or to refute it. So far we have but an hypothesis with some circumstantial evidence in its favor: a few phenomena of an organism, or of a living being will now be considered, which seem to prove *positively* the truth of the proposition *that life is produced by forces which are evolved by the decomposition or oxydation of the organism*. We will examine a few of the experiments which *Nature* is continually performing before our eyes, and see to what conclusion they would naturally conduct us. Reference has been and will be made to Dr. Carpenter's work, because it is the standard work of the day, as well as our textbook.

#### 5th. Arguments from the phenomena of the organism in a *normal condition*.

First, of "*Dormant Vitality*" as it is called. This is a phrase manufactured to explain the condition of a seed previous to germination. No doubt it originated in the difficulty to account for the life which becomes manifest under proper conditions, if it did not exist in the seed before, though *asleep*, and only needing to be *waked-up*. Whatever may be said of *phrase explanations* as a general thing, here at least, it seems to involve greater difficulties than it obviates. To make it at all satisfactory, it is necessary to explain how a thing can be neither dead nor alive, as is contended to be the condition of a seed before it germinates.\* It would seem as reasonable to say, that two and two may not make four, as to say that a thing which is not alive, may at the same time *not* be dead. The germ is but *one condition* to Life, and therefore does not possess life of itself. We are told by all, that air, heat and moisture are "*stimuli*" to arouse this drowsy life from its sweet repose. To say the least, it is not more probable that air, heat, and moisture, are not respecters of person, but act upon a germ in no other way than they do upon any other organic compound, and that life action is produced by the forces evolved in the oxydation, or decay of the organism when thus under the influence of these conditions.

The very idea of Life involves that of *action*. In fact, it is to the *actions* of an organized structure that the term *Life* is applied; for without action there is no Life. Now, there can be no action without some agent to produce it; and this agent, or agents, must have existed, in part at least, in the seed prior to germination, and they *may* be said to constitute the *principle of Life*, but not in the ordinary acceptance of the phrase. In the *time piece*, gravitation is taken advantage of, and, in that instrument, becomes the motor force. If it would be a source of gratification to any individual, he *might* call

\* Carpenter's Human Physiology, § 255.



it, as here applied, the *principle of the clock*, if he did not convey by that phrase, the idea that it was something *distinct* from gravitation as exhibited elsewhere. Words are but the expressions of ideas; I do not, therefore, contend against the phrase—"the vital principle"—but against the ideas which it is used to express. Although there *must be* agents to produce vital actions, yet I contend that, as in the clock the motor force is not distinct from gravitation elsewhere, so in the germ, advantage is taken of the *ordinary* forces and properties of matter, and that there is no agent at work in the organism distinct from the forces which belong to the matter which constitutes it. It is contended that there is no independent agent created with the germ in a *sleepy condition*, only needing to be waked up into action by "*stimuli*," which, when thus *excited* into action, overrules the ordinary tendencies and gives direction to chemical action; but, that vital actions result *from* the ordinary forces as directed in the organism. It may be objected that the natural tendency is to disorganization, and this is true; but it is no objection to the general proposition; for the tendency to disorganization may be the starting force to the whole machinery. To show this possible, in addition to the argument already drawn from inorganic chemistry, let us consider an analogous action in physics: The force of gravitation gives all matter upon the surface of the earth a direction to the centre, so that the natural tendency is "downward;" but man can, by *his* ingenuity, so direct this force as to raise bodies *upward*. Let there be two railways upon an inclined plane, for instance; a car descending from the top by the force of gravitation, may be so attached to another at the bottom as to draw it up. The action of the ascending car is directly contrary to gravitation, yet gravitation is the acting force. We can see the tackle and the ropes attached, and prove mathematically how gravitation may be the acting force to *elevate* weights; and no one imagines the existence of an independent agent which he calls the *inclined plane principle*, whose office it is to overrule gravitation and produce action contrary to it; for, although the action is contrary to the ordinary direction of gravitation, yet he sees the process, and knows that, so far from there being an independent agent overruling gravitation, it is gravitation itself that produces the action as directed by the ingenuity of man. So in the organism; so far from there being an independent agent to overrule the natural laws, properties and forces of the matter composing the organism, it is these forces themselves that produce vital actions, when peculiar directions are given to them by the means taken by an infinitely wise and just God for the accomplishment of His own ends. It is true we cannot see the whole process as in the example of the inclined plane above cited, yet it is unphilosophical to suppose an unknown agent, unless the known ones are proved insufficient, and it is shown that the natural tendency to disorganization does not prove such an agent necessary.

Perhaps it would be well to carry the above analogy a little farther. To be able to direct gravitation so as to *elevate* a weight by it, it is necessary to have a weight also at the top of the inclined plane; so, for the act of organization, it is necessary to have an organized structure for the starting point, and as the descent of one weight is the means by which another is elevated, so disorganization is means of organization. Here we arrive at the necessity of a first great cause; as there must be an organized structure *before* there could be disorganization. But again, if the weights of the two cars were equal there would be no action; because there would be a balance of forces, and consequently, no tendency to move in either direction, though gravitation is no less *energetic* than if it were producing action: So in the seed prior to germination there is a balance of forces, and consequently, there is no action

though the forces are *no less energetic* than if they were producing life action. If an additional force be applied to one ear, the balance is disturbed and action necessarily results, but the additional force did not "*stimulate*" the original force of gravitation; so when air, heat and moisture are applied to a seed, the affinity of the germ for oxygen disturbs the balance of forces, and *vital* actions result, but air, heat and moisture *could not* act as "*stimuli*" to any force originally in the seed. But we are told not only that there is in the seed an independent vital agent, but also, that air, heat and moisture are "*stimuli*" to excite it into action. More upon this subject hereafter.

The hypothesis that matter was originally endowed with vital properties, is certainly more objectionable than the theory of a vital principle. Some objections have already been offered to this supposition (†). The argument in favor of it is simply this; if we had but four senses, those things of which we become cognizant by the fifth, would be unknown to us; so having five senses, there may be many things of which we are ignorant for want of proper senses to recognize them; and *therefore*, matter *was* originally endowed with vital properties, and we have no evidence of the fact for want of proper senses to recognize them until it becomes organized. Are we to receive every hypothesis as true, until it is proved false? The presumption against it, is a sufficient cause to reject it until evidence is brought in its favor. But we are lulled in our ignorance upon this subject by being told that it should be received as an ultimate fact. The theory of one independent vital principle created with the organism is rejected, and in lieu of it, one is offered which gives to every particle of matter an independent vital principle, created with the matter itself, and developed by the act of organization; for, it is said, that, by the new circumstances in which the matter is placed in the organism, properties, which were previously *dormant*, are caused to manifest themselves.\* But not only is presumption against this hypothesis, but all analogy is opposed to it. The properties of *water*, for instance, do not exist independently of the combination of oxygen and hydrogen in the proportion of one equivalent of each. But this combination always gives us water with its peculiar properties, be it formed wherever it may. Though neither oxygen, nor hydrogen possesses the properties of water, in a separate condition, yet they possess properties which give them the *susceptibility* of forming this compound with its peculiar properties. So it is with the organism; though the various kinds of matter capable of assimilation do not possess vital properties, in a separate state, yet they were originally endowed with properties which give them the *susceptibility* of forming an organism with its peculiar properties. As the properties of water *originate* with the combination, so the properties of an organized structure *originate* with the combination. The organism cannot, strictly speaking, be said to possess *vital properties* itself; for, life may be said to be the sum of the actions of an organized structure, but there is no action in this structure, unless it be under the influence of certain external agents; therefore the susceptibility of action is the property, and not the action itself.

Not only have we the causes heretofore stated, for rejecting the theory of an independent vital principle created with the organism, and the theory that matter was originally endowed with vital properties, which are "caused to manifest themselves" by the act of organization, but there seems to be still more direct and positive evidence against them. We read in our text-book that all vital phenomena are dependent upon at least two sets of conditions—"an organized structure possessed of peculiar properties, and certain stimuli by which these properties are called into action."† From the context we

\* Carpenter's Human Physiology, chap. xiv. § 782.

† Ibid., chap. iv. § 258.



learn that the word *properties* is used to express *dormant forces*; hence the above conditions would read thus—an organized structure possessed of peculiar *dormant forces*, and certain *stimuli* by which these *dormant forces* are called into action. In considering the conditions of Life, as above expressed, let us first see what idea we have of the meaning of the word *force*. What does it express, if it express anything at all? It is used to express that agent which produces, or tends to produce action; if it be not producing, or tending to produce action, it is not a force; if it be dormant, it is not thus producing, or tending to produce action; therefore, if it be dormant, it is not a force, and consequently, the phrases *dormant forces* and *dormant vitality* seem to be philosophically absurd. The two words contradict each other. It is just as impossible to annihilate force as it would be to destroy matter; but the very act of a force becoming dormant would be an act of its own annihilation, and therefore, a force cannot be dormant. As there is the same amount of matter now that there was at the creation, so there is the same amount of force; nothing has been added to or taken from it. If a force do not produce action, it is not therefore dormant, but is balanced by a counterforce. Gravitation is acting no less energetically upon all bodies upon the surface of the earth than if they were unsupported in the air, though in the latter case it would produce action, and in the former it does not; in every case it is tending to produce action. But again, we are told that certain *stimuli* excite these dormant forces into action. Stimulate a force! If it be a force at all, it is already in action, and cannot be stimulated or depressed. It is true the action may be increased, but this can only be effected by adding other forces, or by changing the *direction* of the existing forces. As matter cannot be increased or diminished, but can be variously combined as to produce very different compounds, so force cannot be increased or diminished, but may be variously combined and directed as to produce very different resultants. If any number of forces were so directed that separately they would make a body describe all the sides of a polygon, when all these forces act in their respective directions at the same instant, they would not tend to *move* the body in any direction, for their energies would be exhausted in neutralizing each other. If the same forces were differently directed, they might cause violent action; but they would not be any more energetic themselves than when they did not produce any action. Take gunpowder, for instance; it may be preserved for any length of time without change; but, if a spark be applied, violent action ensues. The spark could not *stimulate* forces which were dormant in the powder, but simply gives a new direction to forces which previously were neutralizing each other, or rather disturbing the previous balance of forces.

When the above considerations are observed, it seems that the condition of a seed, before germination, loses its peculiar mystery, and its explanation becomes comparatively easy. The phrase—"dormant vitality"—is the received explanation at the present time; but I have attempted to show that there can be no such thing as dormant vitality, and, moreover, if there could, that the external agents could not *stimulate* it into action. It is contended that if there be forces in the seed, and there must be, these forces must be in action, though they may not produce action; and that the only way air, heat, and moisture, or any other agents, can produce action in the seed, is either by their additional force or by changing the direction of the existing forces, and thus disturbing the balance. The facts in the case are simply these: A seed may be preserved any length of time without undergoing the slightest change; but, when certain external agents are applied, life becomes manifest. The object is to interpret these phenomena, just as we would those which present

themselves in any artificial experiment. This experiment, performed for us by nature, is brought forward in support of the proposition—that *life action is produced by forces, which are evolved*, or take a new direction, *in the decomposition of the organism*. The seed does not possess vitality, in any sense of the word, before germination; it does not even possess *life force*, either dormant or in action, for life is only produced when it is under the influence of certain external agents, and, therefore, life force is the resultant of forces as directed by the seed under the influence of these external agents. Therefore, we have life force only under the co-operation of *all* the conditions of life; but its *components* have existed and been in operation since the foundation of the world, or the creation of matter. Now these *components* are not mysterious agents which never manifest themselves except in organized structures, but the very same forces which produce the *ordinary* chemical actions, when directed by an organism under the influence of these external agents, become the components of life force. But organization *must be* produced by means of disorganization, because the natural tendency of an organized structure, under the influence of the external conditions of life, is to disorganization; and consequently, organization cannot be *directly* produced by the ordinary forces. But, as no means or ingenuity whatever could make gravitation *directly* elevate a weight, yet, as has been seen in the case of the inclined plain, it may be made to do so *indirectly*, by means of depressing a weight, which is its natural tendency; so no fortuitous circumstance or event could ever make the ordinary forces of matter *directly* produce organization, yet they may produce organization *indirectly* by means of disorganization, which is their natural tendency. From the foregoing considerations, therefore, it is concluded that life *originates* when the seed is placed under the proper conditions, through decay or oxydation, which these conditions naturally induce.

Secondly, of Hybernation and analogous conditions. These are conditions where life seems often entirely arrested after it had once existed. But, we are told that life is not entirely extinct; that the "*Vital Principle*" still remains, and the animal is not dead, though it may be frozen in solid masses of ice, so that, if it should fall, it would break into pieces; for, say they, when the necessary "*stimuli*" are applied, this "*Vital Principle*," which had become *dormant*, is *excited* into action again, and the animal lives as before.\* Not a small amount of credulity is necessary to make such an explanation satisfactory. But, perhaps this is the best explanation which could be given upon the *supposition* that there is some agent in the organism, different from those which are derived from the ordinary properties of the matter constituting it. The fact that these simple experiments performed by nature, are opposed to such a supposition, is a sufficient reason, of itself, why we should reject the theory of an independent Vital Principle, and of the original endowment of matter with Vital Properties. But, the fact is, we set to work to torture nature's phenomena, so that we may reconcile them with some previously conceived hypothesis, or theory; instead of *basing* our theories upon these phenomena. Though, in the seed before germination, and in a frozen animal, there is not one of all those phenomena, to the aggregate of which the term *Life* is applied; yet we must *believe* that there was vitality in them in their inactive condition rather than give up some previously conceived theory! But we will compromise the matter somewhat, and call it "*Dormant Vitality*," regardless of the sacrifice of principles! The same objections which have been brought against Dormant Vitality in a seed, apply equally well here; for, the two conditions have been explained by a sort of circle; that the condition of

\* Article *Life*, in the Cyclopædia of Anatomy and Physiology.



a seed is precisely similar to that of a torpid animal; and the condition of a torpid animal is precisely similar to that of a seed. The fact that forces cannot be dormant, and cannot be stimulated, seems a sufficient objection to this explanation. Upon the supposition that *Life is produced by forces which are evolved in the act of decay*, the explanation becomes easy and natural. As the temperature, which is a condition to decay, diminishes, decay must also diminish; and as decay of an organism is the means by which life-force is produced, the diminution of decay would diminish life-force accordingly. If the temperature be so much diminished as to arrest decay, life must consequently cease; not in part, but entirely. This state of *death* may continue indefinitely, so long as the external conditions are preserved. But with the return of heat, if the structure have not been destroyed, decay, and consequently, life commence again as in the original germ; and, whereas the animal was *dead*, it is alive again.

Similar conditions are observed, or effects produced in animals and plants, when air, or moisture—other conditions of decay and life—is excluded. In the same article referred to heretofore, in which it is contended that life has no tendency to diminish decay, but simply *counteracts* its destructive tendency by constant renewal; it is also said that air could not have been entirely excluded from the *toads* and other *reptiles* which have been extricated from solid rocks and trees, and restored to life; for, it is said, there must have been a *little* life left to *prevent* decay, and the entire exclusion of air would have destroyed life. Now, it would seem, that the exclusion of air itself would *prevent* decay, or rather, would deprive it of the tendency to decay; and it is most likely it was *entirely* excluded, else aliment would have been required. When air was returned to these animals decay commenced as a natural consequence; and, as the organized structure had been preserved, life commenced as a no less natural consequence when all the conditions were thus fulfilled. The same may be said when similar effects have attended the abstraction and return of moisture. It will be observed, that if any one of the conditions of life be taken away, there is no more tendency to disorganization than there is to organization. Decay is not a matter of course, but takes place according to definite laws. Since, then, there is a tendency to decay *always* when *organic matter* is under the influence of all the external conditions of life, and as there is a tendency to organization *only* when an *organized structure* is under the influence of the same conditions, therefore, it is inferred, that decay of an *organized structure* affords conditions under the influence of which there is a natural tendency to organization, if material capable of organization be present.

Thirdly, of Equivocal Generation. Observation has tended to establish this mode of generation, but it has been rejected upon theoretical views. Those who deny this mode, say, although the Entozoa have no prototype in nature, yet, germs taken into the system produce different animals on account of the peculiar circumstances of their position. This is begging the question; for, this is itself equivocal generation. That a germ is *necessary* to life is admitted and presupposed in the theory of equivocal generation, yet it has been accustomed to be considered equally absurd with *spontaneous generation*. Reasoning, *à priori*, from the proposition that life is produced by the decay of an organized structure in the presence of a fluid plasma, we are led to suspect this mode of generation, though there might be an inclination, at first, to confine it to plants and animals, consisting of a single, or a very few cells. But when it is considered that all animals and plants are made up of cells, and that the growth of the individual consists in the growth and reproduction, or multiplication of cells, our original suspicion might be somewhat extended. If it be true that the organism is not endowed with any vital principle, or force

distinct from its own structure, then nutrition and generation—both equivocal and what is called regular—are involved in no greater mysteries than the ordinary chemical actions; but, upon the theory that there is a germ force distinct from the forces derived from the matter constituting the germ, then, both regular and equivocal generation are equally inexplicable; for they both seem directly opposed to this theory. Admit it true, for a moment, that the germ derives a certain amount of life force from its parents; now a force cannot increase of itself, and, if life force increase with the growth of the individual from the germ, upon what does it feed? The quantity of matter of the body may be increased by additional matter taken in; so, if the force increase it must be by additional force; but life force does increase, else reproduction would involve the death of the parent. Now, if life force be something peculiar and distinct from the forces of the matter that constitutes the organism, whence does the individual derive this additional force? The natural inference is, that it is not distinct, and is derived from the additional matter that becomes organized; and if the additional force be thus derived, why not the original force of the germ also? Hence, the very fact that there is reproduction in any mode whatever, is a strong argument in support of the idea that there is no agent at work in the organism distinct from the agents which produce the ordinary chemical actions; that it is the organism itself that makes the distinction. If it be the independent vital principle that determines the species and its constancy,\* there could be no deviation from the original type, for, an offspring could not have a different vital principle from that which its parent had, and consequently, could not transmit one different from that which it received. Now, while it is admitted that the transmission of peculiarities from generation to generation is the great law, when we consider animals and plants in their highest state of development, yet, it is contended that this end is obtained universally, by means of equivocal generation. To prove this, it is only necessary to notice the development of a germ; to observe the various phases of the embryo from its origin to its final destination, instead of confining our observations to the fully formed animal; and, to reflect that a single cell was the common origin of all plants and animals of the most complex, as well as of the simplest structures. It is contended here that the forces which produce vital actions are the ordinary forces of matter, and are evolved in the decay of the organism, because the phenomena of reproduction and nutrition seem to indicate it. The theory of a peculiar *vital* agent has been a veil to hide from view the real nature of these actions, because it makes the cause and regulator of them a mysterious *something sui generis*. The more this agent can be made unlike those with which we are acquainted, the better. It produces actions in matter; in this, it possesses the character of a force; but it is not a force, for it can become *dormant* and can be *stimulated*: it is a *contrary intelligence*; for, it produces action only when opposed—it produces *organization* only under the conditions of *disorganization*: it is endowed with a *creative* power, for it can increase of itself, and multiply without number, as in the processes of generation. In fact, it is in the first place assumed to be a *mysterious* agent, and then, the very contradictory nature of its attributes is considered an argument in favor of, rather than against it.

In considering the above views of reproduction, it would be well first to notice some examples where each generation possesses a distinct individuality, while it is, at the same time, entirely different from that which preceded it—examples where every third, fourth, or fifth, or even tenth generation only, resemble each other, while each generation is distinct and independent. The

\* Principles of Zoology by Agassiz and Gould, § 129.



development of the *Distoma* from the egg, is a good instance to illustrate this point. An animal is developed from the egg, named the *grand-nurse*. This animal gives birth to numerous other animals dissimilar to itself; these are called the *nurses*. These, in their turn, give birth to other animals not in the least resembling the generations preceding; these are the *Cercariæ*. The *Cercaria* is metamorphosed into a *Distoma*, and now, for the first time, we have an animal resembling those that produced the original eggs. Among the *Aphides*, it is only after eight or ten generations from the egg, that the perfect animal appears with the distinctions of sex. These examples are sufficient to illustrate the position, that the development of an animal from the egg is progressive—that the perfect state is arrived at, sometimes, at least, through the successive steps of equivocal generations. Various inferences are deducible from these facts, in reference to the subject before us. The first is, that there may be reproduction without the union of the sexes. It is true, some have supposed that there was a superabundance of *sperm* in the original egg; that this being taken up by the young animal, *vivified* germs produced by it; that the superabundance still existing, being taken up by these young animals, was similarly appropriated in the production of their young, and so on, for many generations. But this only shows how *facts* are twisted, to reconcile them with theories. The simple facts would seem to indicate that there was no spermiatic influence except in the original egg; that the *grand-nurse* itself affords conditions for the origin of the *nurses*; and that the *nurse* itself gives origin to the germs of *cercariæ*; that the *distoma* is developed from the *cercaria*; and that the union of the sexes in this state, gives origin to the eggs. Again, upon the theory of a peculiar vital agent, there could have been but one in the egg; say this produces the *grand-nurse*, if you please; now the *grand-nurse* possessing but one vital agent, gives birth to an immense number of *nurses*, of course, each possessing an independent *vital agent*; now, each one of these *nurses*, possessing but one vital agent, gives birth to an immense number of *cercariæ*, of course, each possessing an independent vital agent. Also, the more complex animals are composed of an innumerable number of cells or organisms, which are only dependent for their action upon those external conditions which life action in general is; but the original germ, from which the cells composing the complex animal were developed, could have possessed but one vital principle. The important question here is, where did all these independent vital principles come from? They could not be produced by the subdivision of the original one in the egg or germ cell, supposing such a thing possible; for each successive generation is carried to a higher state of development than the former, which could not be the effect of a *part* of a *vital principle*. But suppose, for a moment, that a vital agent does exist in each of the *cercariæ* which are finally developed from a single egg, that they do originate in some way, no difference how; all these must be of the same *kind*, at least, as the one which developed the *grand-nurse* from the egg; for, if it were admitted possible for the vital principle to multiply indefinitely, it would still seem impossible that it should change its character. So, admitting the existence of a vital principle, it is necessary to admit also, that the peculiarity of the individual is not dependent upon *it*, but upon the peculiar organization of the germ itself; for, if the *same agent* produces at one time a *grand-nurse*, then a *nurse*, and then a *cercaria*, animals entirely different, the difference must necessarily result from the peculiarities of the material acted upon. Hence, though all animals have a single cell for their common origin, yet the peculiarities in the structure of the future animal, are entirely dependent upon peculiarities in the composition of the germ itself. The constancy of species,

therefore, is not dependent upon the vital principle, admitting one to exist, but upon the constitution of the germ itself. Hence, the dumb agents which produce the ordinary chemical actions, when directed by the germ, could produce all the vital actions as well as an *intelligent* vital principle, if the exercise of *intelligence* is unnecessary."

But it may be objected that the foregoing argument is irrelevant; for, we do not know the nature of the *vital principle*, and, therefore, should not argue upon it as if it were analogous to anything we do know. This objection would put a stop to all investigation; for it is always necessary to reason from the known to the unknown. Whatever it may be which produces life, it certainly does not only resist decay, but produces actual organization; therefore, it is a force. If it be a force, it must possess all the properties of force in general, and must be reasoned upon accordingly. As force cannot be created or destroyed, *life* force, therefore, is but a peculiar combination of forces which have existed since the creation, as *organized* matter is but a peculiar combination of matter which has existed since the creation.

Perhaps it would be well now to notice the development of vertebrate animals, and see what analogy exists between their steps towards maturity, and those of the Distoma and Aphides just considered. First, notice the formation of the germ itself. In the evolution of the spermatozoa, suppose that the "parent-cells" are evolved immediately from granules which are secreted by the tubuli seminiferi; these parent-cells give birth to the "vesicles of evolution" and die themselves; the "vesicles of evolution" give birth to the spermatozoa and die themselves. Thus, the development of spermatozoa from granules secreted by the tubuli seminiferi, is precisely similar to the development of the distoma from the egg. The evolution of the ovum from the ovisac is the same. It is the received opinion that the germ-cell is formed by the union of the spermatozoa with the ovum. While this union gives origin to the *germ* of a new being, independent vitality existed prior to it, as is indicated by the evolution of the spermatozoa and the ovum. All this is just what would be expected, if we admit the proposition that *life force is the resultant of the ordinary forces of matter as they are directed in the decay of the organism*. But our observations must not stop here; we now have the "germ" of a new being. All animals and plants have their origin in a single cell. This germ-cell is not a miniature of the future animal; it has not a backbone with a spinal cord having a ganglionic expansion; it has not an alimentary canal, liver, kidneys, and a pulsating heart; it has not muscular and nervous tissues with organs of locomotion. Yet it is all that the parents contribute to the production of a new being, which, after a long series of progressive steps, acquires all the peculiarities of its species, having all the organs necessary to organic and animal life. The diversified cells which compose the various tissues and organs of the fully-formed animal, must be produced by equivocal generation, as they did not exist in the germ. While the *animal*, through its various changes, maintains its distinct individuality, its elementary structure is undergoing the changes of equivocal generation, just as if, in the evolution of the distoma, the "nurses" should not separate, but continue together so far as to constitute but one individual, and the cercariæ, to which these "nurses" give birth, should continue in the same individual and constitute part of its structure. Thus, the animal would undergo various metamorphoses; but would not at any time lost its individuality. So far as observation has gone, it tends to establish the view here taken; that the various changes which the embryo undergoes in its development, are due to equivocal generation of cells constituting it. An animal is a compound organism made up of tissues which are composed of cells. The animal, there-



fore, would change with the cells; these cells are very diversified in the fully-formed animal, but they all originated in a single germ cell. Now each cell which enters into the composition of the most complex structure, is an independent organism as much as if it were separate; its actions are only dependent upon the same conditions that life action in general is. It is plain, therefore, that it is just as reasonable, *à priori*, that the various cells composing a fully-formed animal, should be evolved by equivocal generation, starting from the germ cell, as, that the distoma should be evolved by equivocal generation, starting from the egg; and, if we reject the theory of a peculiar vital agent, there is nothing, *à priori*, against either. The original germ only affords conditions for the *first* act; that act of the germ affords conditions for the next, and so on continually; so that there is a continual progression from the original cell to the fully-formed animal, each act affording the conditions for the next: "the present is the offspring of the past and the germ of the future;" break one link in the chain, and the whole machinery is destroyed. Metamorphosis, therefore, is only the change of form which the individual undergoes on account of its elementary structure being changed by equivocal generation.

If the above view be true, it is evident that the *material* determines the *form* as well as the vital actions. The *material* is all that the parents contribute to the production of the germ, and consequently to the production of a new being. Vitality does not *originate* with the germ cell. The germ cell is the *effect* of vital action; and vital action too entirely independent of the parents. The epithelial cells of the tubuli seminiferi are *part* of the parent, but the material which they secrete is *independent*; and though in this condition it appears formless, and does not show any sign of life, yet this is all the parent contributes in reproduction. The changes which take place after are entirely independent of the parent. When this secretion is under the influence of proper conditions, the "parent cells" appear which commenced with the change of *material* produced by these conditions; the forces thus evolved carry the *interior* to a higher state of organization. When this material thus prepared is under the same influences, life action and cell growth commence in it, and "vesicles of evolution" are produced. These prepare the material from which the spermatozoa are developed. The spermatozoa and the germinal vesicle of the female mingle their contents, which *material* is the foundation of a new being. This view is confirmed, not only by the fact that the ova of some animals are fecundated after their expulsion from the body, but also by the fact that the spermatozoa of some animals are developed after the ejection of the seminal fluid. A good illustration is also found in the development of epithelium cells from a formless material—the *basement membrane*. It is true cells are sometimes partially developed within other cells, but the parent cells only furnished the material or germs and a nidus for their early development, as the womb of the mammal only furnishes a convenient place for the early development of its young.

But not only is *reproduction* accomplished by means of equivocal generation, but it would seem that nutrition is also. Formerly, all actions which take place in the system were referred to the *vital principle* to the exclusion of chemistry; now, certain actions, such as digestion, are found to be chemical, and straightway their vitality is denied. Vitality is not incompatible with chemistry, and why may not the same action be *both* vital and chemical? An action is no less chemical because it takes place in the body; it is no less vital because it can take place out of the body, when those conditions which are supplied in the body are supplied out of it. Digestion is now considered *purely* chemical; this does not prove that it is not at the same time *purely* vital. If the proposition be true, that *vital actions are produced by forces*

which produce the ordinary chemical actions, as they are directed in the decay of an organism, all vital actions are purely chemical actions. As the same force which gives motion to machinery of man's construction, as the water wheel, the clock, &c., in the hands of the Almighty causes the apple to fall to the earth, and regulates the planets in their orbits; so, the same forces which cause the ordinary chemical actions, in the laboratory of Nature, give life to the lichen, rear the gigantic oak, and build up the wonderful structure of man.

It is not contended here that in nutrition each new cell is not as a general thing, similar to the one whose place it supplies in the tissue, more than it would be that the offspring is not similar to its parents. But this is the goal of assimilation arrived at by successive alternate or equivocal generations, starting from certain nitrogenized compounds or germs in the alimentary canal and lymphatic system; just as an independent individual similar to its parents, is the goal of reproduction arrived at through successive alternate generations, starting universally from a single germ cell. When air, heat and moisture are applied to a seed, decay commences, life force is produced, and germination is the natural consequence. If a seed be ground to powder, and air, heat and moisture applied, each separate particle of the germ, in its decay, would evolve life force as much as if the seed had been left entire—as is observed in fermentation; but as the force of all the granules is not concentrated as it would be in the perfect seed, there is not produced an individual plant similar to the one which produced the seed. As the formless material secreted by the epithelial cells of the tubuli seminiferi, contains germs of cells from which are evolved by equivocal generation, the spermatozoa; so, the formless material secreted by the glands emptying into the alimentary canal, contains germs of cells which commence the wonderful process of converting an aplastic into a plastic material. The fact that digestion can take place out of the body when the gastric juice is furnished, is no argument against its being a vital action, for the conditions of *life* are a germ, a fluid-plasma, air and heat, and it matters nothing *how* these may be furnished. If it were possible to supply all the conditions artificially, life would result no less than if supplied by nature; but, as the natural tendency is to decay, and life is produced by the decay of an *organism*, the germ *cannot* be produced except by a previously existing organism. If the germs be furnished by *nature* and the other conditions by *art*, the actions which follow would be the same as if all were furnished by nature. Therefore the fact that the gastric juice will dissolve food out of the body, does not prove it not a vital action; though if our proposition be true, it is chemical also, as well as all other vital actions. Coagulable lymph is effused in a fluid state; soon cells begin to be formed, and after a time they are united and form a solid tissue; so the secretions which are discharged into the alimentary canal would be expected to be fluid, though they contain germs needing only proper conditions to be speedily developed into cells. These cells are not similar to the epithelial cells which produced the germs, therefore they are equivocally generated, as are the epithelial cells themselves; for they are not produced by epithelial cells, since the *basement membrane* has a different origin. Thus the process of nutrition as well as reproduction, commences from germs secreted by epithelial cells, and is a process of equivocal generation.

But not only is digestion an evidence of the truth of the proposition that life is produced by forces evolved in the decay of an organism, but the whole process by which the nutrient material is elaborated, is no less striking. By means of cell-growth, the material prepared by digestion is given up to the *lacteals*. That which is received by the *lacteals* and *lymphatics* is far from



being fit to supply the demands of the tissues caused by their constant decay, but in its passage along these tortuous tubes, it gradually becomes more and more assimilated to the blood. This fluid passes through numerous *absorbent glands* in its course, and no doubt receives from them germs of other cells which contribute much to the subsequent changes. As a perfect animal is produced from an egg by means of equivocal generation of cells, so the blood is elaborated by means of cells equivocally generated. Not only are nitrogenized molecules afforded by glands emptying into the alimentary canal, and the lymphatics above-mentioned, but the thymus and thyroid glands, the supra-renal capsules, and the spleen, all seem to have a similar office in preparing germs whose development performs important functions in the elaboration of the nutritive material. It is thought that the function of the thymus is to store up *nutritive materials* for a time of need, which is great in early infancy. But this does not seem correct when we consider that this gland increases most rapidly in size during the early part of *extra-uterine* life—the very period that the demand for food is greatest; so, instead of contributing to this great demand that which it had previously *stored away*, it still takes more than it gives. This, therefore, is evidently not the function of the thymus gland; but as its functional activity is greatest when the general demand for food is greatest, it would appear that its function, as that of the other glands of which we have spoken, is to prepare azotized molecules or germs important in the preparation of the plastic material. The germs of cells are not miniatures of the parent cells more than germs of animals are miniatures of the parents; one cell does not produce another, but it produces the material or germs from which other cells are developed under proper conditions; it produces the germinal granules, while cell growth is an independent action when under the influence of the conditions of decay. As the epithelial cells are the essential part of the secreting apparatus, the secretions do not contain cells, but the material in which life is produced under proper circumstances. The liquor sanguinis is fluid, but cells are quickly developed in it when it exudes for the reparation of injuries, and comes more immediately in contact with the air; the basement membrane does not contain cells, but cells are constantly being developed from the granules composing it. The liquor sanguinis, the basement membrane, and the various secretions do not exhibit a single phenomenon of life until exposed to the conditions of decay, but then life quickly becomes manifest in the production and growth of cells. The points which have been considered under the present head of equivocal generation, seem to go far to prove that there is no such thing as an independent vital principle, but that vital actions are produced by the forces, which produce the ordinary chemical actions, when these forces are evolved or directed by an organism in a state of decay or oxydation.

6th. Arguments from the phenomena of the organism in a *diseased condition*.

The phenomena of the healthy and diseased actions considered together, are as the perpendiculars bisecting the chords of *two* arcs of a circle, which indicate its centre. All the phenomena of life meet in one point, which is the central law; our present object is to trace them to this point, and find where they meet. In tracing the phenomena of disease, let us consider

First, Depression. In the healthy condition there is a constant balance preserved between decay and renewal. But, for the preservation of this balance it is necessary that *all* the functions should be performed in a fixed relation to each other; there cannot be proper renewal of the tissues unless the blood be properly elaborated, and be acted upon by the proper forces to cause the assimilation. For the proper exercise of all the func-

tions, it is necessary not only that there should be a supply of proper food to be converted into blood, but that the whole system should be under the influence of certain agents called "Vital Stimuli;" the chief of which are air and heat. A reduction of any one of these conditions produces a *depression* of the vital actions below the proper standard. It will be observed that those agents which are called vital stimuli are the conditions of decay; and, therefore, it is the reduction of the conditions of decay that depresses the vital actions, and consequently, the vital actions must be dependent upon decay.

But the mere depression of the vital actions is not a disease; it is a disturbance of the balance between decay and renewal that constitutes the disease. It is evident that a function may be performed *slowly* without being *deranged*, as a man may work slowly and yet do his work well. If decay be slow, it is necessary that the nutritive functions should be below the natural standard, to preserve health. If decay and the nutritive actions be both *equally* below the natural condition, the actions that do take place are still normal. But, in *warm-blooded* animals, it is seldom that depression exists for any length of time without being either the cause or effect of actual disease, from the simple fact that the ordinary causes only produce *partial* depressions; this disturbs the due relation, and consequently, there is *derangement* of functions. The ordinary standard of actions is that which is determined by the ordinary circumstances; but there is no reason to believe that the existing circumstances are the *only* ones under which the actions could be *healthy*. For instance, if the atmosphere contained several per cent. less oxygen than it does, there is every reason to believe that its simple effect would have been to reduce the *standard* of vital actions. In a patient recovering from an acute disease, we have an example of depression without disease. The actions here are below the ordinary standard, yet they are healthy. The organism is so much reduced that there is but little to become oxydized, and I contend that it is on this account that the vital actions are proportionably low, and not because the "vital principle" has been *sick* or asleep. Again, in old age the energies gradually fail, and the vital actions become more and more reduced, until at last life may cease without disease. Here the organism becomes more and more firm, and less easily acted upon by the ordinary agents, until at last the oxydation is not sufficient to keep up the necessary actions of life, and the individual dies. Again, the vital actions may be reduced from hemorrhage, but if the patient be kept perfectly quiet, so that *all* the functions are equally reduced, there would be depression without disease. Here the blood is reduced, which is both the great oxydizing agent and the organizable material; so the proper relation may still be preserved among all the functions. These examples are sufficient to show that mere depression of the vital actions does not constitute disease; but in cold-blooded animals the examples are more striking. In these there is no particular *temperature* at which the healthy vital actions take place, as in the warm-blooded, and the animal is dependent upon external circumstances, and not upon internal chemical action, for its temperature; so, as heat is a necessary agent to decay, cold is an ordinary cause of *universal* depression in these animals. They become torpid, but not diseased from the reduction of temperature; they may be frozen, and life entirely extinct, but, if heat be properly applied, life begins again. From these facts it is evident that it is the diminution of decay that depresses the vital actions, and, consequently, the forces which produce vital actions are evolved in the decay of an organism; it is also evident that health is entirely distinct from vital activity—that there is no standard of vital activity apart from the circumstances under which the vital actions take place, but there is



a *relative* functional activity from which health is inseparable. Application of this fact will be made under the next head.

Secondly. Of increased action. As those causes which diminish decay *decrease* the vital actions, so those causes which increase decay increase the vital actions. Now, to say the least, it seems absolutely impossible that the same causes which produce decay directly in *all* organic matter, should, under any circumstances, *directly* produce a contrary action. But the facts are—it is *only* when an organism is placed under the influence of circumstances which tend to cause its destruction that life becomes manifest, and the increase of these increases life action; so it seems impossible to believe anything else, if we were so disposed, than that these causes produce life action *indirectly* through decay, which is their natural and only tendency. But the inquirer after truth will never find it if he look through a glass colored by prejudice; he must view the evidence face to face, and be disposed to admit the truth, let it come from whatever source it may—let it lead to whatever results it may. He must be disposed to admit it though it compel him to give up favorite theories, and to break attachments formed even in youth.

As the mere depression of the vital actions does not constitute disease, so, conversely, the mere elevation of the vital actions does not; for if the vital actions of a patient left in a prostrated condition by an acute disease, be physiological, and be physiological still after he has gained his full vigor, it is evident that healthy action is not confined to any particular grade. The actions may not be diseased though depressed—they may not be diseased though increased, if *all* be proportionally increased or diminished. If, therefore, mere decreased or increased action does not constitute disease, why do these conditions so often accompany disease; or why do the ordinary causes of excitement and depression produce disease?

The answer to this question brings us to an important point in the subject now under consideration. The individual is composed of organs which are made up of tissues, the elementary parts of which are cells. The cells are the laboratories in the development of which all the vital chemical actions take place. It is the chemical actions which accompany their development from germs or granules, that constitute the sum and substance of organic life. The function of an organ is determined by the cells which compose it when placed under the proper conditions for their normal actions. Now, while every *germ granule* constitutes one condition for the development of a cell, still its normal actions are dependent upon other conditions furnished only by the *joint* agency of the whole individual; the *germ granule* is produced by the actions of a single cell, but the actions of this parent cell were dependent upon conditions afforded by the whole individual, of which it formed a very small part. The conditions, for which the development of cells from granules is dependent upon the individual, are a fluid plasma, oxygen, and heat. If all the above conditions co-exist in their normal state, life is inevitable, and the actions must be healthful. The laws of life are as invariable as the laws of inorganic matter. As a ball in motion cannot deviate from a right line of itself, no more can a healthy living being depart from health without the force of some noxious influence. If a body be moved by the resultant of any number of forces acting in different directions, a *proportional* increase or diminution of all the forces would not change the *direction* of the moving body, but would simply affect its velocity: so, if *all* the conditions of life are *proportionally* changed, the actions will still be normal though increased or diminished according to the change of the conditions. It is evident, therefore, that the *derangement* of the conditions of life must be the cause of disease. Now, the ordinary cause of depression or of increased action, is a change in only one or two of the condi-

tions of life, and that change often only exerted over part of the individual. It is from hence that these states of system are so closely associated with disease, while they are entirely distinct from it. If, therefore, it is the actions which accompany the development of cells from granules or germs that constitute organic life, it is plain that if oxygen and heat act upon these germs disproportionately to the plastic condition of the blood, there must be diseased action. It is plain that the conditions of decay may exist to a greater extent than the conditions of renewal, as the blood is elaborated by a long process and changes its plastic condition comparatively slowly, while the conditions of decay may be changed instantaneously. I think it will appear, therefore, that disease attended with excitement, or depression, consists essentially in the disturbed relation between decay and renewal, or oxydation and nutrition. It has been shown that if *all* the conditions of life were proportionally increased, the actions would still be normal; so, when oxygen and heat are increased—without which there could not be increased action—and there is abnormal action, it is inferred that this results from the want of a proportional increase of the plastic condition of the blood. This view will be confirmed by what is to follow.

When the causes of inflammation are considered, it is observed that whatever cause tends to produce greater *decay* in a part than takes place in health, tends to produce inflammation in that part. To illustrate the position taken in this essay, that the forces which produce life actions are evolved in the decay of the organism, it will only be necessary to notice the increase of one of the conditions of life. Let us take Air for instance. If *air* be admitted into a shut sac or tissue from which it is in health more or less excluded, inflammation is the result. We know if air be entirely excluded, there could be no decay or life in the part; if it be partially excluded, as it is from the internal parts of the body in health, decay must be limited in proportion. If now a free access of air be admitted to parts from which it had been partially excluded, decay increases above the natural standard in proportion to the extent to which the air had been naturally excluded; but the free access of air produces *inflammation*; therefore, increased action or inflammation is produced by increased decay or oxydation. If the surface be denuded of the skin, the most approved practice is to exclude the air, as far as possible, from the part affected, and thus prevent the increased decay, and consequently, inflammation which the free access of air would tend to induce. The coagulable lymph, first thrown out in a wound in contact with air, is converted into pus, which is a means of nature to protect the part from the influence of air. If the edges of a wound be brought together, so as to exclude the air as in nature, union may take place without inflammation; so, when inflammation does occur after a wound, it must be referred to some influence which did not exist in the case where a cure was effected without it. There is every reason to believe that this influence is the air, which increases decay, and consequently, causes inflammation. The fact that there is increased life-force where there is increased decay, makes inflammation a recuperative act, which otherwise would be only destructive. If life-force were not evolved by decay, the balance between decay and renewal would not be so constantly preserved as it is in health:—in disease, it is the secret of the "*vis medicatrix naturee*."

If life *force* be evolved by decay, there must be decay prior to life *action*. Now action is proportional to the force impressed, and consequently, in health there would be a constant relation between decay and life action. If a body held together by cohesion be moved, *all its parts* must be moved together; if a slender cord be attached to a part of it, and a force be slowly and steadily applied, a body of heavy weight may be moved; but if the force were



suddenly applied, the cord would be broken without moving the weight, because it requires *time* for the force to be brought to bear upon the whole mass; so if life force be *suddenly* applied to a *part* of the organism, it will produce disease, because it requires *time* to change the action of the whole machinery. Now, if life force is evolved by decay, and it requires time for this force to produce its legitimate action, if the conditions of decay be suddenly increased, it may go on to inflammation corresponding to the suddenness and extent of the increased decay before the actions of the whole system correspond to the rapidly increased force. In every living being there are two sets of actions constantly going on—one of disorganization, the other of organization. In health, organization is in proportion to disorganization, or decay; but, in health, organization is in proportion to the life force; therefore, life force is in proportion to decay, and it is inferred that it is evolved by decay. It is evident that decay is in no way dependent upon organization, except as it furnishes the material to decay; but decay may be increased suddenly, while the force thus evolved cannot *instantly* pervade the whole system and raise the plastic condition of the blood, so that the organization in the *part* may increase proportionally and simultaneously with the increased decay, especially as the *whole system* is nourished from a *common* circulating fluid. And disease consists essentially in this—a disproportion between disorganization and organization.

In cold-blooded animals, injuries are repaired *without* inflammation. This is just what would be expected *à priori*, upon the supposition that life force is evolved in the act of decay, and that inflammation consists in a disproportion between decay and renewal. For the act of decay it is necessary that the following conditions should co-exist: A material to decay, moisture, air, and heat; now in warm-blooded animals the morbid cause is like a coal applied to *dry* wood, which takes fire and evolves heat sufficient to keep up its own combustion; but in the cold-blooded, it is like the same application to *wet* wood—the heat is absorbed in the evaporation of the water, and consequently, the temperature of the wood is not raised sufficiently to cause its combustion. The temperature of these animals is not sufficient for much increase of decay, and increased decay in them would not increase the temperature; so there is no chance of those causes which produce suddenly increased decay in the warm-blooded animals, producing the same effect in the cold-blooded, and, consequently, there is no chance in them of that disproportion between decay and renewal which appears to constitute inflammation.

Again, upon the supposition that all *morbid excitement* consists essentially in a disproportion between decay and renewal, and consequently, that life force is evolved by decay, it would be expected that such excitement *might* exist in any condition of system or grade of vital activity; but it would be expected that slighter causes would produce disease in the debilitated, because slighter causes would disturb the balance in such a state of system. Now let us consider the facts in the case. If an individual place his hand into warm water, he may, with impunity, gradually increase its temperature to an extent which would produce inflammation in a hand *suddenly* plunged into it. This is an example not only of the different effects produced by *suddenly* increasing the conditions of decay, and by increasing them to the same degree *slowly* and *steadily*, but it shows that the same cause which would produce *morbid excitement* in a part at the natural standard of vital activity, would not produce the same effect when the vital activity is increased. Again, if a part be much reduced below the natural standard by cold, a degree of heat which before would have been pleasant would now not only cause pain, but would actually produce inflammation. But a part even partially frozen may be re-

stored to its vital activity without inflammation if the temperature be increased very slowly and gradually. These facts prove positively, it appears to me, that life force is evolved by decay; that it requires time for the force to produce its legitimate actions, as in physics; that over-excitement consists in a disproportion between decay and renewal; and that this disproportion is more easily produced the more the vital actions are reduced. Admitting the truth of the first conclusion, the other three would follow as natural consequences; so observation, showing that morbid excitement is more easily caused by increasing the conditions of decay when the vital actions are depressed; that in morbid excitement there is greater decay than renewal; and that in all physics it requires *time* for force to overcome inertia, goes far to prove the truth of the proposition that life force is evolved in the decay of the organism.

If morbid excitement consists in the disturbed relation between decay and renewal, it is evident that excitement may be produced either by increasing the conditions of decay, or by diminishing the conditions of renewal more rapidly than those of decay. The effect of increasing the conditions of decay has been somewhat considered already; it remains to notice briefly the effect of diminishing the plastic condition of the blood. The blood is both an oxydizing agent and the common pabulum of the whole system. It is thought that the constituent of the blood which conveys the oxygen to the tissues is distinct from the *nutritious* material; that the former is performed by the red corpuscles, while the fibrin is appropriated to nutrition. Now, while it is contended that *all* life actions are produced by forces evolved in decay, and that without decay the blood could not be elaborated, yet it is plain that there might be causes which would affect the *actions* without directly affecting the forces. For instance, no forces whatever could make proper blood from insufficient or unwholesome food; again, a morbid cause might be introduced into the blood which would first affect its plastic condition. But as decay evolves the forces to produce renewal, so renewal furnishes the material to decay; consequently, these two sets of actions are mutually dependent upon each other, and whatever would affect one, would secondarily affect the other. It is in this circle of action and dependencies that consists the *vis medicatrix naturæ*. The cause of disease, whatever it may be, disturbs the balance; the mutual dependence of decay and renewal upon each other causes a tendency to a restoration, and, as soon as this is effected, though the patient may be much debilitated, there is a change from diseased to healthy action. Now decay must be prior to renewal, or the force before the action; so, at the commencement of fever, decay may be as great as in health, but if the plastic condition of the blood is so deranged that renewal is less, the next act of decay must be less because the same amount of material to decay is not furnished; and if renewal is still less than decay, the next act of decay must be less than the former, and so on, the patient becoming more and more debilitated, though the cause of excitement will continue until the cause of disease is removed, and a restoration of the balance between decay and renewal is effected. However heavily this may grate upon the ears of those who are accustomed to look upon the *humoral theory* as entirely exploded, still there is sufficient evidence to prove that the condition of the blood has much to do with fever. Reasons will hereafter be given for the opinion that the actions of the heart, and of the nervous system (other things being equal) are entirely dependent upon the conditions of the blood. The observations of Andral prove that the *fibrin* increases in simple inflammation much above the natural standard, while in continued fever it is much diminished in proportion to the red-corpuscles.

The proposition that *life force is evolved in the decay of the organism*, is



confirmed by the means which nature takes to cure disease, or by the observed natural tendency to health. The fact that in inflammation the blood becomes more and more plastic, proves that the forces which produce fibrin are increased in inflammation; that is, the increased disintegration increases the plasticity of the blood, or the very act which increases the demand increases the forces to supply it. But, in inflammation, renewal is not so rapid as disintegration; therefore the material to decay is constantly becoming less, while the plasticity of the blood is constantly increasing; so, here is the tendency to an equilibrium, or a balance between decay and renewal. So in continued fever, where the morbid cause resists the efforts of nature, the fever and excitement show that she is making these efforts to restore the equilibrium, and so soon as the cause of disease is removed she will accomplish her object, as life force increases and diminishes with decay. If any cause should increase decay, there is a recuperative action set up in the system; for the same cause would indirectly increase life force; if any cause diminish decay, there is also a recuperative action set up; for the same cause would diminish life force accordingly, and consequently the structure would be more easily influenced by the ordinary conditions of decay.

Again, the evidence in favor of this proposition derived from reaction and remission must not be passed over without notice. "*Excitability*" is a word used to express an hypothetical agent supposed to reside in the system and produce these phenomena. It is fancied that excessive action *exhausts* this excitability, while it is *recruited* by repose. Observation proves that excessive action is followed by a state of depression, and depression by increased action, but the received notions about excitability as an agent producing these phenomena, are but flights of the imagination. The explanation explains just nothing at all, because the essential part of it is altogether hypothetical and mysterious. The objections which were brought against the "*vital principle*" under the head of Dormant Vitality, hold equally against "*Excitability*;" that is, against the ideas which excitability is used to express. When a part has been exposed to severe cold, it is said to be more easily excited because its *excitability* is increased by repose: would it not be better to give the old woman's explanation in simple terms—"It is so because it is!" But the word is not confined to this simple meaning; it is used to express an independent agent supposed to be the efficient *cause* of reaction and remission—of excitement and depression, as it is capable of becoming tired and recruited again. The following is found in one of our most popular text-books: "It must be admitted that the system has a limited *amount* of excitability; but it is not true that the *whole* of this excitability is called into play in health. It is easily conceivable that, by augmenting the *stimulation* applied to all the organs, the *excitability in reserve* may be brought into action." It is apparent from the above phraseology that the word excitability is very convenient to explain much, but I confess my inability to conceive how "*excitability in reserve*" can be stimulated into action, as it is a *passive quality* and not an *active agent*. Water is expansible by heat into steam, but heat does not *stimulate* its expansibility into action. If the heat be increased, the expansive force of the steam is increased, but the heat is not a stimulation by which the expansibility *in reserve* is brought into action—heat is the *force* which *produces* the expansion. Now, heat is evolved by the oxydation of combustible matter; increase this oxydation, and all the actions dependent upon the force of heat are increased accordingly; but an increase of the *conditions* of combustion, such as fuel, oxygen, &c., does not stimulate the expansibility of steam *in reserve* into action—it simply increases the force upon which the actions depend. So in the organism, I

contend that the conditions of life do not *stimulate* excitability into action, but that they produce oxydation or decay by which the forces are evolved which produce life actions. Increase these conditions, and life force is increased, and consequently, life action; hence the susceptibility of the organism to oxydation or decay gives to it the property of excitability. All action is in proportion to the force impressed; so when action is increased, the force is increased and not stimulated. Hence, those agents called "Vital Stimuli" do not stimulate life force or "Dormant Vitality" into action, but they induce the oxydation of the organism by which those forces are evolved which produce life actions.

Reasoning, *à priori*, from the theory that life-force is evolved by the oxydation of the organism, exacerbation, and remission, depression, and reaction, would be expected when the equilibrium should be disturbed in disease, from the fact that the same cause which increased decay would indirectly increase life-force, and the cause which diminished decay, would diminish life-force; and from the fact that depression and excitement consist essentially in a disproportion between decay and renewal. The important points pertinent here, have been already sufficiently noticed and need not be repeated.

Again, if it be true that life-force is evolved by decay of the organism, and that *nutrition* as well as *reproduction* is a process of equivocal generation, it would be expected that the boundary fixed by nature might, by some cause, be broken down, and equivocal generation continue beyond the point of assimilation; this state of things is observed in malignant growths. It would also be expected that there might be from malformation, or rather from the want of adaptation between the subjective and objective conditions of life, a failure of the energies before the goal of assimilation should be reached; this state of things is observed in tubercular deposits and other degenerations. The coagulation of blood is a vital action produced by the rapid oxydation when this fluid is brought in more direct contact with air.

7th. Arguments drawn from the respective functions of the Muscular and Nervous Tissues.

The fact is now well established, that the functional activity of these organs is attended with a proportional disintegration. Hence, for an individual to take violent exercise, decay must be rapid, and we find the actions of the heart and lungs increase accordingly. In an impoverished condition of the blood, these actions are likewise increased. The final cause of this is evidently to supply more nutritious material to the tissues where it is required, but the direct cause is not so evident. The action of the heart is said to take place from its own "irritability," and that of the lungs from force, or "nervous influence," sent down from the medulla oblongata. But how does the irritability know to increase, and the far famed medulla oblongata know to let loose its "influence" just as an increased supply of blood is required in the system, as shown in the two *very different* conditions above? This information is said to be given by "sympathy," which is certainly made a very intelligent existence, if not intelligible. Again, a great amount of *force* is required to keep up the actions of the heart as well as other muscular tissues: Now, "irritability," can no more be the force to produce these actions, than "nature abhors a vacuum" is the force which raises liquids in a tube from which the air has been exhausted.

Physiologists have well ascertained that the action of the intestines and the heart are not dependent upon nerve motor-force; why then refer the action of other muscles to this force when nature always works by *general* laws? Again, if a muscle, or nerve passing to it, be touched with the point of a scalpel, contraction takes place, though separated from all connection with the



nervous centres. Now, it is evident that the scalpel could send no force to the muscle to contract it, though it was instrumental in inducing the contraction. These facts seem to be sufficient to prove positively that the muscular contractile force is not derived from the nervous system.

Another view which it is necessary to notice briefly, is, "that irritability is a property inherent in muscular tissue, and that the agency of the nervous system upon it is merely to call it into active operation." Call the irritability into active operation! Irritability is a passive quality and consequently could not be called into active operation. The objections brought against the application made of "excitability," are equally applicable to that made of irritability. The irritability of a muscle is its susceptibility to action under the influence of the proper force, but it cannot be the force itself. If it were a force itself it would act of itself; for a force cannot be *stimulated*. But it is said in our text-book, that the "contractile force may remain *dormant* for a great length of time in the muscular structure, until called into operation by the appropriate stimulus."\* The contradiction involved in the idea of a *dormant force*, and the impossibility of *stimulating* any force, have already been considered under the head of "Dormant Vitality." It must be remembered that the prevailing views respecting a "muscular contractile force" and the "nervous influence," are altogether hypothetical, and consequently, are to be received only as they are corroborated by facts. It is proved that muscles contract under the agency of the nervous system; but the views entertained of irritability as an inherent force, and of nervous influence as an *agent* to *stimulate* this contractile force into active operation, are but theories formed to explain the phenomena. But the explanation is not satisfactory, because it takes for granted that a force can be dormant, and can be stimulated, which are not self-evident facts at least; and moreover, it assumes unknown forces—the muscular contractile force and nerve force, while it is not proved that the known forces are not sufficient.

As "irritability" and nerve "motor force" have been rejected, it remains at least to attempt some other explanation of the phenomena. Let it be granted that there can be no action without a force, and that the action is in proportion to the force impressed; from hence it would follow, that a force cannot be *dormant* or *stimulated*. For any theory to hold it must be capable of explaining all the phenomena; for nature does not act at random, but all her actions are in accordance with general laws. Therefore, any theory respecting the origin of the motor force of muscles, must explain the *rhythmical* action of the heart as well as the action of the voluntary muscles; for it is as necessary to tell why an action ceases, as to tell why it commences. The fact that there is disintegration of the muscular tissue in proportion to its functional activity, would suggest electricity to the mind as the motor force, as, in a battery, it is evolved by the chemical action, and is in proportion to the oxidation of the metal. The striking resemblance of the muscular fibrillæ to the arrangement in the electric fish, would also suggest the idea of electricity. It has been, and still is the theory of some, that the *nervous agency* is identical with electricity, but reasons will be given for the belief that no influence is communicated from the nervous centres to the muscles; that the force which contracts the muscles is electricity, and that this force is evolved in the muscles themselves. Let us now consider some of the phenomena of muscular contraction, and see how far they go to support this view.

In considering this subject, the muscles will be made to represent compound batteries made up of fibrillæ; the nerves, to represent the poles; and the nervous

\* Carpenter's Human Physiology, § 256.

centres, the places where these poles are united, instead of where motor force is generated. For the action of a battery, two conditions are necessary; it must be *charged* with an oxydizing liquid, and the *poles must be united*. Consequently, there are two ways by which the action of a battery may be arrested; either by discharging it, or by disuniting the poles. Now this view seems to explain the actions of the muscles, without the necessity of making force susceptible of becoming dormant, or being stimulated, and without involving the difficulties of those mysterious agents—"muscular irritability," and "nervous influence." *The contraction of the heart not only forces the blood from its cavities, but also from its tissue or substance*; consequently the contraction ceases, not because there is no blood in the cavities to *stimulate* it, but because the oxydizing liquid has been driven from the muscular tissue by its own action, and the electricity, or motor force ceases to be evolved when the oxydation ceases. That the contraction of the heart forces the blood from its own structure, is apparent from the necessity of the case, when it is considered that *action and reaction are equal*. The pressure of the blood in the cavities upon the heart is equal to the pressure of the heart upon the blood; consequently, its contraction tends to force the blood both from the cavities and its own structure. Again, with very few exceptions, physiologists agree that *all* the diameters of the heart diminish in the contraction of the ventricles; and, when the direction of the muscular fibres is observed, it would be difficult to believe anything else. Now it is evident that the contraction must force the blood from its tissue, if all the diameters are diminished; and it must be remembered that those who observed the heart to elongate in the contraction of the ventricles, were endeavoring to account for its impulse against the chest; but this phenomenon seems more naturally explained upon this well-known physical law—that fluids press equally in all directions, and consequently, when the resistance is removed from one direction by the opening of the semilunar valves, there is a force tending to drive the heart in an opposite direction equal to the force by which the blood is driven into the aorta and pulmonary artery, and as the heart is comparatively loose, this force is sufficient to cause the impulse against the parietes of the chest.

Again, that it is important that the contraction of the heart *should press the blood from its substance*, is proved from *final causes*, or the evident marks or design in the position of the orifices of the coronary arteries. These arteries arise just at the free margin of the semilunar valves, the very position in which they would be most protected from the propulsive force of the heart. As the blood rushes into the aorta during the systole of the ventricles, it jets over the edges of the semilunar valves, so that the coronary arteries are perfectly free from any influence tending to propel the blood into them during the contraction of the heart. Also the *direction* of these arteries is very disadvantageous for the reception of blood during the contraction of the heart, while it is very advantageous if the blood be forced into them by the contraction of the aorta during the diastole of the ventricles. These facts not only prove that the contraction of the heart *does* force the blood from its substance, but the evident marks of design show that it is to accomplish some important object.

As the contraction of the heart discharges the battery, the evolution of electricity ceases; but, in its dilatation, blood is not only driven into the cavities, but, by regurgitation from the aorta, into the substance also. When the conditions for action are thus again fulfilled—when the battery becomes charged—contraction takes place again, and thus the rhythmical action continues so long as there is a supply of oxygenized blood. In this way the heart is constantly being charged and discharged. With this view, in order



to account for the correspondence between the wants of the system and the action of the lungs and heart, it is not necessary to make the cells of the system little independent intelligences which communicate to another independent intelligence—"sympathy"—its wants with child-like simplicity, and "sympathy," with great fidelity, makes these wants known; and now, as the lungs and heart are cognizant of the fact (or the "nervous centres which send down their stimulating influence"), they make great exertions to supply these wants with a parent's tender care. The heart and lungs, or the nervous centres, do not deserve the credit of *parental affection* which has been ascribed to them; it is their own selfish conditions which produce increased or diminished action; but it is so arranged in infinite wisdom that the heart, the respiratory muscles, the nervous centres, and the general system, *all sit at a common table*, where a common circulating fluid is served up. The dilatation of the heart is, no doubt, produced in part by the contraction of the aorta forcing blood into its substance, and partly by the force of the blood returning to the cavities; but the chief cause of the dilatation seems to be the *elasticity* of the muscular fibre. The experiments of Schwann prove that the *power* of a muscle diminishes with the degree of its contraction, which would be the case if the muscular fibre be elastic, for its resistance would constantly increase with the contraction. If the motor force should overcome the elasticity of the muscular fibre and produce contraction of the heart, it is plain that when the motor force should cease to be evolved, the heart would return to its original condition. These observations are confirmed by the fact that a *continuous* electric current applied to the heart produces a state of *fixed* contraction.

The voluntary muscles and those in which the actions are of a "reflex" nature, are dependent upon a different condition for their contraction. Whereas the heart contracts only when it is *charged*, these muscles, being charged, contract only when the poles are united. The "afferent" nerves, no doubt, have a ganglionic expansion, as is contended to be the case with the nerves of special sense by our distinguished Professor of the Institutes, Dr. Jackson. The act of deglutition may be considered a type of reflex action. The material to be swallowed pressing upon the nervous expansion in the fauces, unites the nervous filaments, which causes an action in the medulla oblongata, which action unites the "efferent" nerves, or rather unites the poles of the muscles of deglutition, and contraction occurs simultaneously. To illustrate—in the magnetic telegraph an impression is made by an operator, and an action corresponding to it takes place in a distant city; now this action might be so arranged as to unite the poles of a second battery, and there would be an action in the second battery corresponding to the original impression made in a distant point; so the impression made upon the *afferent* nerves causes an action in the nervous centres; this action unites the *efferent* nerves, and an action corresponding to the original impression is produced in muscles. The same explanation may be given of the action of the voluntary muscles, except, instead of the action being caused by an external impression, the Will has control of these muscles, and presides over their actions.

Taking the above view of "reflex action," it is not contended that it has not some influence in the actions of the heart. The single fact that muscles may be made to contract by a *mechanical* impression when removed from all connection with the nervous centres, proves that the motor force is not derived from the nervous system, but is evolved in the muscles themselves. The fact that "irritability" is no force at all, but simply indicates the readiness with which the motor force is evolved, and the susceptibility of the muscle to its influence, proves that *irritability* is not the *active agent*. It may be well to sum up some of the facts in support of the doctrine that muscular motor force

is electric, and is evolved in the muscle itself; that a muscle is a compound battery, and the agency of the nervous system is to unite the poles. 1. The resemblance of a muscular fibrilla to the arrangement in the electric fish, and the fact that the electric discharge in these is under the control of the will, and is followed by exhaustion. 2. The disintegration of a muscle is in proportion to its functional activity, as the evolution of electricity in a battery is in proportion to the oxydation of the metal. 3. Electricity evolved externally applied to a muscle, or transmitted along the nervous trunk, produces its contraction; a current, transmitted along an "afferent" nerve, causes reflex action, and, if the animal be alive, will cause sensations which are referred to the origin of the nerves. 4. The fact that the rhythmical action of the heart, or of a part of it, may continue after its removal from the body. The observations of Mr. Bowman have proved that the transverse striæ of the muscular fibrillæ approximate each other in contraction, which, of course, would have a tendency to force out any fluid from between them. Each separate fibrilla is a distinct battery, which is discharged by its contraction and charged in its expansion. 5. If a muscle, or the nerve passing to it, be touched by a sharp instrument, contraction is the consequence, which shows that the poles have been thus mechanically united, or oxydation in some way increased as oxydation is in proportion to the action of a muscle. There are many ways of inducing the contraction of muscles, but it will be observed that they all act either by the direct application of electricity evolved in an external battery, or by increasing the oxydation of the muscles themselves, which is effected either by changing the condition of the muscles in respect to the oxydizing fluid, or by uniting the poles. Though the means are very different, they all effect one object, which is to obtain the presence and influence of free electricity. These agents, which cause contraction, are called stimuli. Now, when a so-called stimulus is applied to an individual fasciculus of a voluntary muscle, the contraction is confined to that fasciculus; but, in the muscles of organic life, the action not only continues after the cessation of the impression, but extends to the adjacent fasciculi for some distance. This shows that the voluntary muscles are mainly dependent upon the union of the poles for their action, while in the muscles of organic life the contraction of one fasciculus discharges it, and the fluid thus forced out charges the next which contracts, and so the action continues for some distance, after it has been once started. Again, it is well known that the material in the alimentary canal occasions increased peristaltic movements; but it is well known that it also occasions a greatly increased afflux of blood, so that the peristaltic action is increased because the muscles are more highly *charged*, and not because the material "stimulates the muscular irritability into active operation." 6. The objections to the theory that nervous agency and electricity are identical, do not apply to the theory that muscular motor force is electricity, and is evolved in the oxydation of the muscle. With the view which has been taken, it would be expected, *à priori*, that the experiment of Matteucci upon the crural nerve of a horse would fail, for each nerve fibre being an insulated pole, and these being united in the nervous centres, when the muscle is thrown into contraction there is a current in each direction in the nerve-trunk, and consequently, the equilibrium is preserved, and there is no means in our power to detect its presence. Again, it would be expected that the passage of a ligature round a nerve-trunk would destroy its conducting power for electricity evolved in the muscle, though it would still transmit a current from an external battery; for, no doubt, the fluid within the tubular sheath of the nerve-fibre is the conductor of electricity as evolved in the muscle, and consequently, a ligature pressing in the sheath would separate the nervous matter within, and break



the connection, while the cellular tissue connecting the nerve-fibres, and perhaps the ligature itself, would serve to transmit electricity externally applied.

Another objection urged against the identity of nervous influence and electricity is thus expressed :—"If a small piece of nervous trunk be cut out, and be replaced by an electric conductor, electricity will still pass along the nerve; but no *nervous force*, excited by stimulus above the section, will be propagated through the conductor to the parts below." Now, this is just what would be expected if the motor force be electric and evolved in the muscles themselves; for, if the conductor replacing the piece of nerve cut out, united the nervous matter within the sheaths, contraction would follow in consequence of that alone, as when a "mechanical stimulus" is applied; but, if this conductor be only in contact with the sheaths of the nerve-fibres, and with the areolar tissue and blood-vessels, no contraction will be induced, though the nerves may be united above the point of section; for the connection is broken between this and the muscular battery; yet, the connection between the conductor and the areolar, and fibrous tissues, and blood-vessels of the nerve-trunk, is all that would be necessary to transmit electricity evolved in an external battery. It would be well also to reflect upon the assumption in the above quotation—that nervous force can be excited by stimulus above the section. 7. The explanation of muscular action upon the theory of inherent irritability and nervous force, makes new forces when the known ones are sufficient to account for the phenomena. 8. These new forces are endowed with attributes which do not belong to force in general, such as the capability of becoming dormant and of being stimulated into action.

Of the function of the nerves of special sense similar explanation may be given. It is maintained by Prof. Jackson, that the expansion of the nerves of special sense is ganglionic. It may be important to observe that the observations of Mr. Bowman upon the optic and auditory nerves, prove that the *central part* only of the nerve-fibre, is continued in their expansion; the tubular membrane and the white substance of Schwann being deficient. Moreover, it must be borne in mind that there is no such thing as light, sound, odor, &c., independently of the respective organs upon which impressions are made by external agents. Now the external agent, whatever it may be, unites the central part of the nerve-fibres at their ganglionic expansion, in consequence of which no influence or impression is *sent up* to the brain, but an action takes place *in the brain* corresponding to the external impression. As in the magnetic telegraph, no impression or thought is sent from one city to another, but there is an action in one city corresponding to an impression made in another, and thus, by education, this correspondence becomes a means of communicating thought; so the actions in the brain corresponding to external impressions, become by experience the representative of ideas, or the means by which the mind perceives.

8th. Further evidence in support of the proposition, that vital actions are produced by forces evolved in the decay of the organism, is derived from fermentation. An essential condition of fermentation is the presence of some nitrogenized compound in a state of decay called the ferment. Various theories have been advanced to account for the phenomena, and determine the agency of the ferment. A prominent theory is that of catalysis, the ferment being supposed to act by its *presence*. The greatest recommendation to this theory is its innocency; for, it has not even the appearance of an explanation, and consequently, is not likely to lead astray. An example which is usually adduced to explain catalysis, is the oxydation of hydrogen in the *presence* of platinum. It will be observed that, in a galvanic battery, we have the oxydation of one metal in the *presence* of another which should not undergo any

change. On many accounts it seems that an explanation of the latter phenomenon may be applied to the former. In a common battery, the action is in proportion to the difference between the susceptibility of the two metals to oxydation; so platinum is the best metal to cause the oxydation of hydrogen, yet other metals will produce the same effect more slowly. It is said that these metals have the power of condensing gases, and of bringing them within the sphere of their mutual attraction. Independently of the direct objections to this view, it is of but little advantage, as we are left ignorant of the means by which this object is effected. It is important not to confound the cause and effect, and there is some danger of supposing phenomena to have the relation of cause and effect when they are effects of a common cause. The *nascent* state is thought favorable to chemical combination, because the elements have not then received the gaseous form; but matter in combination possesses a different amount of electricity and heat, from what it does in an elementary state; so, when a constituent of a compound is about being liberated, it may be seized by an *enemy* while it is thus "shorn of its strength." It is also said that the *oxyd of manganese* acts by its *presence* in the decomposition of chlorate of potash. Now, if caustic potash be present, the *manganate of potash* is formed; so, when the free potassa is not present, as in the preparation of oxygen from chlorate of potassa, there is the same tendency for the peroxyd of manganese to take another equivalent of oxygen and form the manganate of potassa; but the nascent chlorine takes the potassium and sets the manganic acid free, which immediately loses the additional equivalent of oxygen, and returns to the peroxyd; this acts upon another proportion of the salt, and returns again to its former condition. So in the end the peroxyd of manganese is found *unchanged* though it had been changed many times. It is not contended that there is any appreciable time between these actions, or that the manganate of potassa is first formed and then the chloride of potassium, but that this is the tendency when they act separately: when they operate together, the action will take the direction of the *resultant*.

Having thus concluded that the *catalytic theory* does not even appear to explain the phenomena of fermentation, it may be proper to notice another theory which obtains to a great extent at the present time; I refer to the *mechanical theory* of Liebig. This explanation is altogether hypothetical, without any facts to support it, so far as I am acquainted. It is imagined that the particles of an azotized compound in a state of decay, must be in motion; that they come in contact with the particles of sugar, *communicate* their motion to the sugar, and thus *mechanically* disturb the balance of forces in this unstable compound; that the constituents of the sugar, now free to do as they please, unite in the form of alcohol, or it may be something else, according to the particular motion it received from the ferment. If the action be thus mechanically produced, one would think that, by stirring a solution of sugar with a stick, it would be converted into alcohol. But suppose a particle of azotized compound in a state of decay, should start off in a tangent after a particle of sugar; as the sugar is in solution, one would suppose that motion, if *communicated* at all, would be communicated to the whole molecule; unless, indeed, it should be attacked by another particle of the ferment upon the opposite side; and then, unless a good imagination furnish a wedge and mallet, it is difficult to understand how it could rive off four equivalents of carbonic acid and two of water, and then split the remainder into equal parts, and thus form two equivalents of alcohol. As it respects the *stability* of a compound, it may be observed that this depends upon, or is relative to the difficulty with which the *conditions* are furnished under the influence of which it is decomposed. Azotized compounds are unstable because they are mostly under the



influence of air, heat and moisture—the conditions under which their tendency is to decay. A wound may be produced mechanically, but no mechanical means could produce inflammation. As it respects any mechanical influence, sugar is very stable, but as the conditions are easily furnished under the influence of which the affinities are changed, it is considered very unstable. Water is considered very stable, but if *free* electricity were as common as the atmosphere, it would be very unstable. Again, from the very nature of the case it is impossible to propagate, or communicate chemical action from one compound to another; but, the chemical action in one may afford the conditions under the influence of which the affinities are changed in another, and consequently, action results. For instance, electricity is evolved by the chemical action in a battery, under the influence of which water and other compounds are rendered *unstable*, and are resolved into their constituents.

Wood, when preserved from the influence of external agents, has no tendency to change; but when *heat* is applied, the carbon and hydrogen become oxydized, and evolve *heat*, which is the condition for further oxydation. The carbon and hydrogen in a state of change do not *communicate motion* to the rest, but the oxydation continues under the influence of the *heat* evolved by the chemical action. Now, the influence of an azotized compound *in a state of decay* is necessary to fermentation, and observation also proves that *cells* are developed in the action. So the oxydation of an azotized compound *evolves forces*, under the influence of which the actions peculiar to these conditions are produced. But it has been contended in this essay that the decay of an azotized compound evolves the forces which produce *vital actions*, and microscopic observations prove that *cells* are developed in fermentation; therefore, I conclude that the act of fermentation is no less a *vital action* than cell growth in the human system, but that they are both at the same time chemical actions. The fact that *cells* are developed in fermentation, which is produced by the *decay* of an azotized compound, proves that *life action* is produced by forces evolved in decay. While each cell in a plant or animal is an independent organism, all the cells together constitute the individual being; so each granule of the germ is capable of taking on life action, but all the granules acting together are necessary to produce an individual after the type of the parent.

The foregoing is some of the evidence in favor of the proposition that all life action is produced by forces evolved in decay. It has been much more difficult to select, than to find arguments in its support. Independently of evidence, *presumption* is in favor of the theory here advocated; for, it is improbable that those agents which produce powerful action in the inorganic world, should not be concerned in the actions of living beings; it is improbable that the great end of electricity, is simply to engage our wonder as it flashes across the heavens, or admiration, as by the ingenuity of man it becomes the means of communicating thought; it is improbable that heat should have no greater object than as the motor force of a steam engine, and that light should be only an external agent to produce vision, or to substitute the pencil and the brush. All this seems improbable when we reflect that living beings were the great end and object of creation. The improbability is increased, when we reflect that the advance of science has been doing away with the mysterious agents and hypothetical notions of former periods, and that there is no more evidence of an independent vital principle, of irritability, excitability, and nervous influence, as *independent agents*, than there was formerly that "Nature abhors a vacuum," and the earth is "flat as a pancake," and of the existence of phlogiston. Now the theory which has been advocated, makes no hypothetical agent; so the evidence adduced is in favor of a

proposition which has presumption on its side, though it is in opposition to theories which have existed in some shape or other for ages.

It may be said, that the doctrine which has been advocated is contradictory to the immortality of the soul. But to the contrary, it seems in direct harmony with that immutable truth. It is an established truth, that the mental actions, which are the manifestation of the soul, are in proportion to the oxydation or decay of the brain, just as the evolution of heat, light and electricity is in proportion to the degree of chemical action. But matter, and the agents which produce its actions, are distinct from the soul; for it is entirely out of their province to generate a *thought*, or fabricate an *idea*, as much as it is out of the province of the mind to produce chemical action; yet, in this life, these agents are the connecting link between the soul and body. As we cannot comprehend the connection between *electricity* and matter, neither can we between *soul* and body; but as the *mental actions* are in proportion to the oxydation of the brain, and as the evolution of electricity is also in proportion to the oxydation, a conjectural explanation may be given how a union of the nerves or of the poles of the muscular batteries may accompany the action of the Will, though the mind may have no *direct* control over matter. As light, heat and electricity, are set free in chemical action, it is improbable that the destruction of matter will be accompanied with the destruction of these agents; and as the mental actions are in proportion to the decay of the *brain*, it is improbable that the destruction of matter will be accompanied with the destruction of the soul. Now, as heat, light and electricity reside in matter, while its change is accompanied with their liberation and escape; so the soul resides in the nervous system, and the mental actions are in proportion to the decay of the brain; why, therefore, may it not be that when "the silver cord be loosed, or the golden bowl be broken," that "then shall the dust return to the earth as it was; and the spirit return unto the God who gave it."





